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FRIDAY, AUGUST 10, 1900.

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*CERTAIN RECENT ATTEMPTS TO TEST THE NEBULAR HYPOTHESIS.**

IT is a far cry from the glacial period to the nebular hypothesis, but yet it is not beyond the view hulloa of logic. Glacial periods have certainly been dependent on atmospheric states, whatever else may have been concerned in causing them. Surely no one will imagine glaciation in the air of the putative molten earth, nor in the warm dense atmosphere currently assigned to the early ages, nor yet in the later periods when figs and magnolias grew in Greenland. If carbon dioxide has the thermal qualities which eminent physicists assign it, continental glaciation could scarcely have occurred while it was a large constituent of the atmosphere. Now the atmosphere has,

* This paper, prepared at the request of the editor of SCIENCE, is little more than an abstract of the following three papers:

I. 'A Group of Hypotheses bearing on Climatic Changes,' by T. C. Chamberlin; *Journal of Geology*, Vol. V., No. 7, 1897, pp. 653–683.

II. 'An Attempt to test the Nebular Hypothesis by the Relations of Masses and Momenta,' by T. C. Chamberlin; *Journal of Geology*, Vol. VIII., No. 1, January–February, 1900, pp. 58–73.

III. 'An Attempt to Test the Nebular Hypothesis by an Appeal to the Laws of Dynamics,' by F. R. Moulton; *Astrophysical Journal*, Vol. XI., No. 2, March, 1900, pp. 103–130.

By 'nebular hypothesis' the gaseous hypothesis of Laplace is always to be understood in this article. The arguments, for the greater part, apply also to all spheroidal hypotheses in convective equilibrium, whether gaseous or meteoroidal.

during its history, contained many thousands of times its present amount of carbon dioxide, as is implied by the vast stores of carbon and carbonates that have been removed from it. We are thus driven to assume either that the early atmosphere was very rich in carbon dioxide, and has been impoverished as the ages have gone on, or that the loss has been made good by supplies received concurrently. In the former case glaciation and similar phenomena dependent on an impoverished atmosphere should be confined to the later ages. But the most extraordinary glaciation of which we have any knowledge took place near the close of the Carboniferous period, or, in other words, far back in the geological series. Vast beds of limestone, coal, and other carbonaceous deposits have since been formed at the expense of the atmosphere's carbon dioxide. Much oxygen and some nitrogen have also been consumed, but we need not dwell on these. If all this carbon dioxide had been in the atmosphere at that time there is reason to doubt whether the glaciation of India, Australia and South Africa could have taken place. Besides, in the Permian and Triassic periods great salt and gypsum beds were laid down over many degrees of latitude and longitude on both continents. These imply an aridity of surprising extent, duration, and intensity, reaching to latitudes not at present affected by appreciable excess of evaporation over precipitation. If the atmosphere had been rich in carbon dioxide, which is believed to equalize temperature and humidity, there is reason to doubt whether these deposits could have been formed. But even still earlier, as far back as Silurian times, before the coal of the Carboniferous period or the carbon dioxide of the great limestones of the Subcarboniferous and the Devonian times had been taken out of the atmosphere, widespread and thick salt beds were formed in the St. Lawrence basin where now the excess of precipitation forms great lakes and a mighty river. Nor is even this the earliest evidence of notable aridity.

Now these and allied phenomena, which imply extraordinary inequalities of atmospheric states, call for a reconsideration of inherited views regarding the constitutional history of the atmosphere. To suppose simply that the atmosphere was once exceedingly rich in carbon dioxide and has been steadily impoverished does not seem to fit the phenomena. But when once a reconsideration is undertaken there is no stopping place short of the original state of the atmosphere, and we are at once involved in the *pros* and *cons* of the nebular hypothesis.

If the nebular hypothesis is approached from the atmospheric side, we must carry into the inquiry the modern kinetic theory of gases or give reasons for dissenting from its validity. In framing the nebular hypothesis a century ago Laplace could not call to his aid the present dynamic conception of gases, and, while this absolves him from responsibility, it makes it the more fitting that the hypothesis should be tested by the kinetic views that have grown out of researches since his day. These views may perhaps require modification in the future, but such modification is more likely to involve intensified molecular activity than the opposite.

Led thus to the subject, we have attempted to make a test of the nebular hypothesis by a comparison of the molecular velocities of the essential gases with the gravitative power of the earth, and its antecedent nebulous ring, to control these at the temperatures assigned them by the hypothesis. We have followed the general method employed by Dr. Johnstone Stoney in discussing the atmospheres of planets and satellites.* The essence of the method is

* 'On the Cause of the Absence of Hydrogen from the Earth's Atmosphere and of Air and Water from

this: The molecules of gases beat upon each other and rebound with great frequency and high velocities. Both the frequency and the velocities rise with temperature. The molecular velocity of a gas is *inversely proportional* to the square root of its molecular weight and hence for the lighter gases it is very high. The velocity of a particular molecule at any instant depends on the nature of the last previous collision, being sometimes much higher than the average velocity and sometimes much lower. Now it is obvious that if a molecule on the outer border of the atmosphere collides with another and rebounds outwards with a velocity so great that the attraction of the earth cannot overcome it, the molecule will fly away into space and be lost. Dr. Stoney has attempted to show that on account of the high velocities thus frequently attained, hydrogen and even helium are not permanently retained by the earth under present conditions. He has also endeavored to prove that the moon and other small bodies cannot retain any of the atmospheric gases, and that this is the reason they are without atmospheres, and this latter view is now quite generally accepted.

Mr. S. R. Cook, however, has attempted to show by mathematical analysis that the rate of loss of hydrogen from the earth is at present too small to be effective,* but he has based his computations on the theoretical parabolic velocity of the earth and not on its available power of control in competition with the sun and other bodies of the solar system, and he also neglected the ionization of the gases and the peculiar conditions of the upper atmosphere.* We have endeavored to show that whatever doubt there may be about the precise competency of molecular velocities to cause loss of the lighter gases at present, their retention would be put in jeopardy if the temperature of the earth were raised to 3500° or 4000° C. as would be necessary to restore the earth to the original gaseous condition postulated by the Laplacian hypothesis. At such temperatures water would be dissociated into hydrogen and oxygen, if not ionized to a higher degree; the molecular velocities of these gases would be exalted by the intense heat† and, in such a state of gaseous extension, the outer part would be far from the center of gravity where the control would be enfeebled.‡ Under such conditions it seems highly improbable that hydrogen could be retained, and hence, the inference that if the earth had passed through such a history it would be deficient in hydrogen compounds. Not only the atmosphere but the ocean would seem to be put in jeopardy.

But this is by no means the crucial application of the test. The Laplacian hypothesis assumes that the material of the earth and moon was detached from the solar mass as an equatorial ring whose diameter was essentially that of the earth's orbit. Now the gravitation at any point on the surface of such a ring would be very feeble —very much feebler indeed than that on the present surface of the moon where no atmosphere is retained. At the same time, by hypothesis, the temperature of the ring was very high, and this high temperature would only prevail if there were frequent and intense collisions. But the rebound from such intense collisions would carry

the Moon,' by Dr. G. Johnstone Stoney, Royal Dublin Society, 1892, and 'Of the Atmospheres upon Planets and Satellites,' by G. Johnstone Stoney. Trans. Royal Dublin Society, Vol. IV., Part B, Oct., 1897. See also Paper I. above cited, pp. 653–683.

*'On the Escape of Gases from Planetary Atmospheres according to the Kinetic Theory,' by S. R. Cook. *Astrophysical Journal*, Vol. XI., No. 1, January, 1900, pp. 36–43.

*See reply of Dr. Stoney 'On the Escape of Gases from Planetary Atmospheres according to the Kinetic Theory.' J. G. Johnstone Stoney, *Astrophysical Journal*, p. 251, May, 1900. *Ibid.*, II., June, 1900, p. 357.

†See table, Paper I., above cited, p. 661.

‡Paper I, pp. 659–661.

the molecules beyond the control of the feeble gravity of the ring, and its dispersion and cooling would seem to be inevitable.* There seems therefore no good ground for supposing that such a ring could maintain either its coherence or its temperature.

But if the ring were dispersed and cooled might it not be reheated to the gaseous condition in subsequently collecting into the globular form? Although a rigorous demonstration is beyond the reach of present mathematical processes, it is possible to make a sufficient approach to a valid conclusion respecting the rate at which such a ring would collect into a globe as to render it improbable that it would heat itself to the requisite temperature or any close approach to it. It is indeed a question whether aggregation would take place at all as the direct result of its own gravitation. Bearing upon this, one of us has attempted to solve a series of specific cases purposely made most favorable for aggregation.† It was assumed, regardless of the probabilities, that an aggregation had already progressed so far as to form a large body having essentially the full gravitative power of the earth and yet it seemed improbable that this body could bring to itself infinitesimal particles from portions of the ring more than 60° distant from itself in heliocentric longitude, unless this were accomplished by other than the simple gravitative force of the earth, the sun and these particles. From this it is concluded that the traditional idea of a hot gaseous ring breaking at some point and gathering into a gaseous globe while still hot enough to maintain the refractory substances of the earth in a gaseous condition, is not tenable, both because of the molecular difficulties and the gravitative incompetencies.

Pursuing this line further, we have inquired whether any single or dominant condensation would take place in a ring of tolerable homogeneity.* Students of the subject are aware that the rings of Saturn are composed of particles of discrete non-gaseous matter and cannot aggregate into satellites because of the differential attraction, or tidal strain, of the planet. They do not illustrate gaseous rings of the Laplacian type on the way to the formation of satellites as once supposed, but quite the reverse. If satellites of equal masses were substituted for them, they would be torn into fragments by the tidal pull of Saturn, and probably redistributed into meteoric rings. The rings appear to represent a state of equilibrium and not a state from which rapid aggregation should naturally proceed, as assumed in the case of the Laplacian rings. The limiting distance within which this power of disruption is exercised by the planet is dependent on its gravitative power and is known as *Roche's limit*. For Saturn it lies a little outside of the outer ring; for the earth, according to G. H. Darwin, it lies about 11,000 miles from the earth's center. We attempted to apply and extend the principles of Roche to cases arising under the nebular hypothesis and in the course of this devised a new criterion of similar nature, applicable to attenuated gases in the form of ellipsoids and rings such as are postulated in the Laplacian hypothesis. For the precise nature of this the reader must be referred to the original paper.† It will suffice here to say that while Roche determined the limits, under assumed conditions, within which disruption would take place, the new criterion assigns the limits, under assumed conditions, within which the aggregation of attenuated or dispersed matter would *not* take place as the result of its own gravitation, in the presence of the superior differential gravitation of the sun. The conclu-

* Paper II., before cited, pp. 658–665.
† Paper III., before cited, pp. 115–117.

* Paper III., above cited, pp. 118–129.
† Paper III., above cited, pp. 122–126.

sion reached by this inquiry was that a Laplacian ring could not have contracted directly into a gaseous globe, and that the nebula out of which the solar system was evolved must have been one of great heterogeneity rather than one of the pronounced homogeneity assumed in the Laplacian hypothesis.

The further question whether the equatorial matter of a spheroid of gas whose rotation was increasing would separate intermittently as rings or go off continuously is not new, but it was thought worth while to reconsider it in the light of modern conceptions of the outer border of an atmosphere or of a globe of gas. This outer border is not now regarded as a defined surface where gravity and 'repulsive force' balance; on the contrary, the outer portion is somewhat like a fountain in which individual molecules are thrown by the rebound from collisions to varying heights, from which they return in elliptical paths, possibly to be thrown back again or to assist in projecting other particles through like paths. There is no theoretical limit to the extent of these excursions short of escape from the control of the main body. The actions of the molecules in this outer portion are therefore more individual and free than those of the denser mass, and in the course of their long free curving paths they may collide in such a way as to become satellites to the main body.

Now the extreme tenuity of the Laplacian nebula seems not to have been considered in connection with ring-formation. One of us has computed that the *average* density of the solar nebula, when extended to the orbit of Neptune, would be 1/191,000,000,000 of that of water.* The tenuity of the extreme outer portion must therefore have been quite beyond the limits of the imagination. In view of this extreme tenuity and the peculiar constitution already cited, it is scarcely possible that there could have been any effective cohesion to prevent the separation of the peripheral portion particle by particle as the individual centrifugal force of each came to equal the centripetal force. It is clear that in a mass of gas densest at the center the centrifugal force would overtake the centripetal force first at the equatorial surface.* The conclusion is therefore that the peripheral matter would have been left behind continuously and that separate rings would not have formed.

Some minor arguments that merely touch the probability of the Laplacian hypothesis may be passed by.†

Arguments of the foregoing class, though they seem entitled to great weight, lack something in rigor, for, at present, exhaustive data cannot be commanded and treated by precise mathematical methods. We, therefore, had recourse to lines of attack of a more mechanical sort. These were found in the relations of mass and momenta. We attempted (1) a comparison of the moment of momentum of the supposed nebular system with the moment of momentum of the actual system, and (2) a study of the ratios of masses to momenta.

1. It is a firmly established law of mechanics that any system of particles rotating about a common axis retains a constant moment of momentum whatever change of form may take place as the result of its own evolution. The evolution of the solar system under the Laplacian hypothesis is such a case. If, therefore, we can restore, theoretically, the supposed nebulous system and compute its moment of momentum, it must be found at all stages the same as at present. The only serious difficulty of the method lies in determining the distribution of density through the postulated nebulous mass. Fortunately this has been at-

* Paper III., above cited, pp. 114.

* Paper III., above cited, pp. 114, 115.

† Paper III., pp. 107–111.

tempted, under some limitations regarding the motions, by some of the ablest of mathematicians and physicists, among whom are Lane, Ritter, G. W. Hill, George H. Darwin, and Lord Kelvin.* The results reached by all are in substantial agreement, though somewhat different analytical methods were followed. The distribution of density computed by Darwin was used in our computations.

The present moment of momentum of the whole system, sun, planets and satellites included, was found to be 22.7666, reckoning the sun as homogeneous, which gives too large results but favors the nebular hypothesis. The unit is a convenient arbitrary one. The moment of momentum of the solar nebula when it reached the orbit of Neptune and had the angular velocity of Neptune, which would be necessary to separate the Neptunian ring, was by computation 4848.055.† These momenta, which should be equal, stand in the ratio of 1 : 213. Furthermore the ratios are different at different stages of the evolution; for example, for the stage just preceding the separation of the earth the ratio of the nebular momentum to the actual momentum was found to be 1 to 1208, and for the stage just before the separation of Mercury, 1 to 754. Larger discrepancies would have been found if the Laplacian hypothesis had not been given the benefit of every doubt as to the structure and of all margins in computation. If for example, the sun be assigned an increase of density toward the center, according to Laplace's law, which is probably near the truth, the last two ratios would be 1 to 1801, and 1 to 1127, instead of the figures given.

For a discussion of the question whether these discrepancies can be due to a radical error in the law of density, the reader must be referred to the original paper.* It can only be stated here that the probable variations from the accepted law of density seem rather more likely to increase the discrepancies than to diminish them, and further that the discrepancies are so enormous that the law must be supposed to quite break down to bring them into harmony. Furthermore it must break down irregularly, for the figures run

Neptunian stage	213
Jovian stage	141
Terrestrial stage	1208
Mercurial stage	754
Present stage	1

To satisfy the laws of mechanics all these should be unity.

2. As the foregoing comparison involves the distribution of density in the supposed gaseous nebula, concerning which there is some doubt, it was obviously desirable to find some mode of comparison which should not involve this factor. This was sought in a comparison between the ratios of the planetary masses to their parent nebula, and the ratios of the planetary momenta to the nebular momenta. In this case the nebular momenta were obtained by adding together the component planetary momenta which they must have equaled under the laws of mechanics. The momenta of the satellites were reckoned in with their respective

* Lane, 'On the Theoretical Temperature of the Sun under the Hypothesis of a Gaseous Mass maintaining its Volume by Internal Heat, and depending on the Laws of Gases as known to Terrestrial Experiments.' *Am. Jour. Sci.*, Vol. XLIX., pp. 56–74, 1870.

Ritter, 'Untersuchen über die Höhe der Atmosphäre und die Constitution gasförmiges Weltkorper,' *Wiedmann's Annalen*, New Series, Vol. LXVI., 1882, p. 166.

G. W. Hill, 'Annals of Mathematics,' Vol. IV., 1888.

Darwin, 'On the Mechanical Condition of a Swarm of Meteorites, and on the Theories of Cosmogony.' *Trans. Phil. Soc.*, 1888.

Kelvin, 'On the Origin and Total Amount of the Sun's Heat,' Popular Lectures and Addresses, 1891. *Constitution of Matter*, pp. 370–429.

† Paper III., pp. 127–128 and Paper II., p. 64.

* Paper II., pp. 65–67.

planets, the estimates of Darwin being used throughout.

Just previous to the supposed separation of the Jovian ring, the moment of momentum of the parent nebula, reckoned from the present moments of momenta of the bodies derived from it, was 14.1816. Now Jupiter has 13.469, or about 95%, of this. But the mass of Jupiter is only 1/1047 of the parent nebula, or less than one-tenth of one per cent. Neglecting for the moment any transfers of momentum that may have taken place afterwards, it appears that, by hypothesis, *the Jovian ring carried away less than one-thousandth of the mass of the nebula, while at the same time it took off 95% of the moment of momentum.* Is such a thing possible in a gaseous spheroid evolving under gaseous laws, or evolving in any form of convective equilibrium? One nineteen-thousandth more of the mass thrown off with an equal proportion of momentum would have left none in the central body!

A similar comparison in the case of the other planets reveals not only very extraordinary ratios but such large and irregular variations in the ratios as could hardly be expected in the systematic evolution of a gaseous body.

To the inquiry whether these discrepancies can be due to subsequent transfers of momentum by tidal friction, the computations of G. H. Darwin have given an emphatic negative; and these are supported by other considerations.*

The general conclusion from these several attempts to test the nebular hypothesis of Laplace is altogether adverse to its tenability. It is equally adverse to any meteoroidal hypothesis which assumes a quasi-gaseous behavior, or an aggregation controlled by the laws of convective equilibrium, as set forth by G. H. Darwin in his memoir 'On the Mechanical Conditions of a Swarm of Meteorites and on Theories of Cosmogony.' The inquiry into the relations of masses and momenta points to an unsymmetrical distribution of matter and energy quite inharmonious with an original spheroidal form of any kind. On the contrary, it seems to indicate that *the origin of the system was such that the outer part acquired all but a trivial part of the momentum while it possessed only a trivial part of the mass.* In specific terms, the outer or planetary part now embraces only about 1/700 of the mass, while it carries more than 97% of the moment of momentum. The sun has no such residual rotatory momentum as to imply that he ever 'threw off' any planets from his equator. If the solar system were converted into a gaseous nebula controlled by Boyle's law and given the existing moment of momentum and allowed to contract, the centrifugal force would not overtake the centripetal until long after the orbit of Mercury had been passed.

The ratios of masses to momenta and the discrepancies of the system clearly have a high value in the construction of a tenable hypothesis, whatever that may prove to be; for they are specific criteria which must be met. In an attempt to construct such a hypothesis, *the matter of the system must be so brought together as to give low mass, high momentum and irregular distribution to the outer part, and high mass, low momentum and sphericity to the central part.* In speculation in this direction the possibility of the initiation of the system by the peripheral collision of a very small nebula upon a large one has seemed worthy of consideration. Assuming that the collision was essentially due to mutual gravitation, the smaller nebula must, from the nature of the case, have had a relatively high velocity, and hence a high ratio of momentum to mass, while the larger nebula may have had little initial rotation, or may even have had a rotation contrary to the present one, which was reversed by the impact, or the recur-

* Paper II., pp. 70–71.

ring series of impacts, of the smaller nebula. So far as we can now see, the most serious difficulty in framing a consistent hypothesis along this line lies in the approximate circularity of the present planetary orbits, but as circularity may result from the combination of a large number of constituents having elliptical orbits, this difficulty may not prove insuperable.

We naturally turn to the heavens for nebulæ whose evolution might give a system of low mass and high momentum in the outer part and high mass and low momentum in the central part. The spiral nebulæ offer the greatest promise of conforming to these demands for they seem to present attenuated outer matter irregularly dispersed and perhaps in relatively high motion, while the central portions are usually denser and seem to possess less momentum relatively, but this is little more than pure conjecture based on their forms, for nothing is positively known of the dynamics of these masses. Professor Keeler has shown by recent photographic researches that spiral nebulæ are the dominant forms among the smaller class. This justifies us in giving them precedence in attempts to find analogies for the origin of our system. This suggestion may really be identical with the preceding, for, in the absence of any knowledge of the origin of spiral nebulæ, it is possible to conjecture that they arose from peripheral collisions of antecedent nebulæ.

T. C. Chamberlin,
F. R. Moulton.

University of Chicago,
July 9, 1900.

THE ILLUSORY DUST DRIFT. A CURIOUS OPTICAL PHENOMENON.

It is of course improbable in the highest degree that the phenomenon here to be described has entirely escaped notice hitherto, but the writer at least is unaware of any existing description of the same. The conditions under which the illusion arises are so easy to fulfill, and the resulting appearance is so odd in many ways, that the readers of Science may be interested in a brief description of the matter. The only 'apparatus' required is a set of black and white lines and a dark background near by. The best results, perhaps, are obtained by using a square yard of common black cloth bearing narrow white lines not more than two millimeters apart. Such cloth may be obtained at any large dry goods store. If now this be hung upon the wall in a strong light, and a square of dull black cardboard be placed above it, or at the side, everything is ready for the observation. Picking out some point near the center of the cloth, let this be fixated steadily for not less than twenty seconds. Then transfer the gaze quickly to the black cardboard, and the illusory dust drift will appear. The appearance is that of *a thin cloud of fine white dust moving across the field of vision.* Or the tiny particles seen may be likened to the motes in a sunbeam, since they much resemble these in density. A steady fixation of the eyes is at no time absolutely essential. They may roam freely over the cloth and then later over the dark background, though the illusion under these circumstances is diminished in strength. The best results are unquestionably secured by as resolute a fixation of the cloth as possible. The necessary *duration of this fixation* seems to depend upon the retinal sensitiveness of the observer. Probably 5 sec. is the minimum for any noticeable after effects, while no advantage seems to be gained in any direction by prolonging the fixation beyond a period of 30 sec. In practice, successive renewals of the illusion may be accomplished by very brief fixations, provided only that the time of the first fixation be moderately long.

The *duration of the illusion* seems also to be an individual matter. One observer can

still see traces of the 'dust' after a lapse of 30 sec., while in another case everything had disappeared at the end of 4 sec. Perhaps 10 sec. would be a fair average duration. At about this time the regular after-image is apt to make its appearance, and this tends strongly to drive the illusion away.

But the really interesting point in the matter is the *direction* of the moving drift. This turns out to be directly dependent upon the direction of the lines in the field of fixation. The most general statement of the matter is that, however these lines may lie, the illusory dust currents run in a direction *perpendicular* to them. Quite often, however, it is impossible to speak of the direction as strictly perpendicular, since the course of the drift may be along curved lines, as if a tiny whirlwind had caught up a bit of light, fluffy snow. Or, further—and this is perhaps most often the case—there are secondary currents visible whose directions do not coincide with that of the main stream. Nevertheless some particular direction is almost invariably more prominent than any other, and the statements of various observers show that the direction of the most vivid stream is most decidedly perpendicular to that of the lines. If the lines are vertical, the drift is usually to the *left*, though some subjects see it always to the right. If the lines are horizontal, the tendency to see the drift running *downwards* seems to be slightly more marked. Nearly as many subjects, however, see an upward drift, and quite often currents are seen to run side by side in *both* directions.

If the experiment be so arranged that half the field of fixation is occupied by vertical and the other half by horizontal lines, two clearly separated currents will appear in the illusion with horizontal and vertical directions respectively. Or if the usual field of fixation be divided by a vertical strip of some uniform color, no 'drift' will be seen in that portion of the field corresponding to the strip. If the centre of a set of concentric black circles upon a white ground be fixated, the resulting illusion suggests a confused boiling movement, sometimes running in converging lines towards the center, sometimes passing in diverging lines towards the periphery of the field.

Now the oddity of this illusion consists precisely in this: that without intentional movement either of eyes or of object, there is yet an after-effect in the form of a definite and unmistakable perception of motion. An ordinary after-image of motion requires a previous objective movement of some sort. Here, on the other hand, we can only say that the resulting perception is *as if* there had been a previous and actually perceived motion. And this latter is exactly the case with another peculiarity not directly connected with the illusion itself. After steadily viewing the cloth for say 30 sec., the closely set lines begin to appear beaded. They are no longer straight, but wavy. And even the after-image when it appears presents the same aspect. Now this result is identical with that produced by actual movement of parallel lines across the retina.* Accordingly we have in connection with this illusion, two phenomena that ordinarily follow actual movement. This fact would seem to indicate the direction in which an explanation is to be sought. For while there is no intended movement of the eyes during the fixation of the cloth, there are certainly *impulses* to movement aroused by the various lines about the fixation-point. Every one knows how hard it is to let the eyes come to rest in a field occupied by such lines. Each one of the latter solicits the center of fixation to rest upon it. The impulses to movement are then in directions perpendicular to the lines,

* This has been well described by von Fleischl, Sitzungsber. d. Weiner Acad. 1882, Bd. 86, III. Abth. S. 8.

in other words, in the same directions as the currents of the illusory dust-drift. And, taking all into account, it cannot be very far out of the way to conjecture that the same fundamental factors are at work here as in the familiar cases of the artificial waterfall and the rotating spiral. Mere impulses to movement have taken the place of actual movements in the production of after-effects.

An attempt to obtain the illusion with *monocular* vision is attended with quite surprising results. For even after a full minute's fixation of the cloth, *no 'drift' is to be seen on the black background.* And the result is the same whether both eyes, or the one eye only, be open at the moment of transferring the gaze to the black surface. There is instead an interesting set of phenomena which do not appear in the binocular experiments. Now the illusory dust-masses come to view *during* the fixation. They are not wholly like those above described, but present rather the appearance of fine meshes formed of light gray cobwebby lines. Sometimes these meshes appear to lie slightly in front of the cloth, and if the effort is made to fixate them they temporarily disappear. Movements are by no means wanting, but there is an intermittence about them which the binocular phenomena never show. A closer examination of this net-work character of the illusion reveals the fact that each eye, the closed as well as the open, is contributing to the total effect. This may be readily demonstrated as follows. Let either eye, the *left* for example, be entirely screened from the cloth by a tiny box, or something similar, blackened within, the eye remaining open and free to move. Let the *right* eye fixate the lines. Now while this right eye remains open, the most prominent illusory movements are decidedly those running *perpendicular* to the direction of the lines. This is true no matter how the lines may lie in the field of vision. But if this right eye be closed after a brief fixation, another set of movements is seen projected into the dark field of the covered *left* eye. These movements, though possessing neither vigor nor great vividness, are invariably in the *same* direction as the objective lines. That which moves here is less a dust-cloud than a set of fleecy or worsted-like bands, in the midst of which the 'crossed' after-image of the lines of the cloth soon appears. In addition then to the regular transferrence of an after-image to the field of the unstimulated eye, we have here the transference also of an illusory after-effect. The illusion is to be sure not wholly the same for the two eyes, but neither are crossed after-images entirely identical in character with the direct after-images. The interesting features then of the monocular experiments are that the illusion appears for the stimulated eye during the period of fixation only, and that the unstimulated eye also presents illusory effects of the same general character as those experienced by the open eye.

It can hardly be said with full certainty that these monocular phenomena have contributed anything decisive towards the explanation of the binocular form of the illusion. Nevertheless there is a point of difference between the two forms which cannot be wholly without meaning. There is, namely, in the monocular experiments a relative absence of the feeling of unrest during the period of fixation. The single eye seems to fixate the chosen point with far less effort. Solicitations to its movement are noticeably absent, and the time of stimulation can be prolonged without discomfort to a point where the binocular stimulation would have become exceedingly disagreeable. Now whether this absence of vivid impulses to movement may be regarded as alone responsible for the difference in the illusion can of course not be affirmed with complete confidence. But it seems

probable on the whole that the ultimate explanation of this, as of all after-images of motion, will be somehow formulated in terms of impulses to movement aroused by the particular stimulation that precedes. Perhaps the experiments here recorded may contribute their mite towards this final explanation, if that ever comes.

A. H. PIERCE.

AMHERST COLLEGE.

RAFINESQUE'S WESTERN MINERVA, OR AMERICAN ANNALS OF KNOWLEDGE AND LITERATURE.

IT has been the writer's good fortune to discover in the library of the Academy of Natural Sciences of Philadelphia a copy of Rafinesque's *Western Minerva, or American Annals of Knowledge and Literature*, of which the only information possessed had been taken from the prospectus published as an advertisement in the *Kentucky Reporter* of 1820. The great rarity of the work is explained by its author in his 'A Life of Travel' (1836), page 66, as follows: "Ever since 1821 I had proposed to publish a literary and learned journal, the *Western Minerva;* subscribers were procured, the printer had also made a contract with me, and the first number was printed; when he dared to suppress it, at the request of some secret foes of mine, who probably paid him for it. I only saved three copies of it * * *."

The copy now under observation is a small quarto, with a page measurement of 113x183 millimeters (exclusive of margins). The matter is printed in two columns to the page, and consists of vi + 82 pages, of which the preface and dedication are not double-columned, and pages 81–88 are without doubt original proof sheets, as they are printed on one side only, and bear corrections in ink of typographical and other errors, with such notes as "I must see another proof," etc.

Aside from the rarity of the work, it contains several articles of extreme interest to naturalists, as new names for plants are proposed which have not as yet been noted in synonymy, or else have not been given such an early date in scientific nomenclature. In bringing these matters to the attention of those interested it has seemed advisable to describe the work from the beginning, referring to the non-scientific articles, or the apparently least interesting of these, by title only.

Western Minerva, | *or* | *American Annals* | *of Knowledge and Literature,* | Un peu de tout, | Food for the Mind, | first volume, | for 1821, | Lexington, Kentucky. | Published for the editors, by Thomas Smith, in quarterly num- | bers, four of which form a volume, at $2 per annum. | 1821.

Page ii. Blank.

Page iii. Dedication, "To the Trustees, President, Professors and Tutors of Transylvania University * * *."

Page iv. Blank.

Pages v, vi. Preface [Dated Lexington, January, 1821].

Page 7. Headed with the title as on title-page to the word literature, with the addition of the following: Containing original essays upon Science, the Arts, Literature, and subjects connected with the Civil and Natural history of the Western States. Vol. I. Lexington (Ky.), January, 1820. No. 1.

Pages 7–11. Under the heading Legislation, is Principles of Political Wisdom, * * * Translated from the Greek by Benjamin Franklin.

Pages 11–18. Ethics, or Moral Philosophy. The Moral Decameron * * * Translated from the Greek * * * by Benjamin Franklin.

Pages 18–22. Metaphysics. Theory of the Creation or Emanation of Beings, etc. [Signed, Leibnitz and dated Lexington, October, 1820].

Pages 22–26. Astronomy. Enquiries on the Sidereal, or Upper Spheres, by Professor C. S. Rafinesque. [Among other things the author recognizes three kinds of comets, and brings forward the names *Dromets* and *Tychomets*. For 'revolving stars' he proposes *Geophosies*. Dated, Transylvania University, 22d October, 1820].

Pages 27–29. Meteorology. Letter on Atmospheric Dust, addressed to Governor De Witt Clinton, Albany. [Signed by C. S. Rafinesque, Transylvania University, 1st, October, 1820].

Pages 29–31. Physics. On a New Property in Light, by Captain Forman. With Notes, by C. S. Rafinesque [pp. 29, 30]. Synopsis of some Discoveries on Heat, made in 1818 [pp. 30, 31. Signed M.].

Pages 31–33. Mathematics. On Descriptive Geometry [p. 31. Signed M.]. On Isomerical Numbers, or Common Multiples [pp. 31–33. Signed Archimedes].

Pages 34–37. Chemistry. Synopsis of the Principal Discoveries, etc., made in 1818 [p. 34. Signed M.]. Chemical Art of Converting pure Woody Substances into Gum and Sugar, etc. (Abridged by Professor Rafinesque) [pp. 35–37]. Selection of late European Discoveries in Chemistry [p. 37. Signed M.].

Pages 37–38. Mineralogy. New Mineral Species discovered or ascertained in 1818 [pp. 37, 38. Signed M.]. Notice on the Hydraulic Limestone, by H. De Witt Clinton, Governor of the State of New York, etc., in a letter to Professor Rafinesque. [p. 38. Letter signed by D. C., and dated Albany, September, 1820. The chemical analysis of the limestone is given by Clinton as follows: 35 parts carbonic acid, 25 lime, 15 silex, 16 alumine, 2 water, 1 oxide iron, 6 loess = 100. An appended note by Rafinesque further describes the material.]

Pages 38–40. Original Scientific Intelligence, or Discoveries and Remarks on Natural Sciences; extracted from a letter of Dr. John Torrey, * * * to Professor Rafinesque. [One of the large tuckahoes from the southern States is given the name of *Sclerotium giganteum*, being the largest species known; the substance of the fungus is a new principle for which the name 'Sclerotin' is proposed. The discovery of Datholyte at Paterson, N. J., is recorded, and a new mineral from Schooley's Mountain, N. J., is described and named Siderographite. *Oryzopsis melanocarpa* Muhlenb. and *O. asperifolia* Mich. are differentiated; the latter is not an *Oryzopsis*, and Muhlenberg's species is referred as a synonym to *Milium racemosum* Smith. The letter is signed J. T., and dated N. York, 28th July, 1820.]

Pages 40–43. Botany. Botanical Discoveries made in Kentucky in 1820, by Professor Rafinesque, extracted and translated from a letter to Professor Decandolle of Geneva, * * * [pp. 40–42. Dated Lexington, 1st December, 1820. The genera *Enemion* and *Stylypus* are characterized, the latter evidently the same as *Stylipus* Raf. (1825), the type being *S. vernus*, in both instances. A new genus allied to *Sedum*, but differing in 'having 4 unequal petals and 4 monospermous capsules,' is named *Aectyson*, with *A. sagittatum*, which has 'cylindrical scattered leaves, sagittate at the base, the flowers in a polystachyous umbel, the petals white lanceolate carinate acute, etc., as the type.' The author suggests that this plant is close to *Sedum pulchellum* and the latter may be congeneric. The relationship of *Jeffersonia binata* to the 'family of Berberides' is noted; that *Rhamnus lanceolatus* Pursh, belongs to the genus *Frangula;* that two species of Buck-eye trees are blended under the name of *Pavia pallida*, which he calls *P. ochroleuca* and *P. axillata*, but gives no descriptions. The genus *Cubelium* is named for *Viola concolor*, which makes the date of establishment of the genus 1821, instead of 1824, as has been quoted. He has ascertained more than

twenty new species of plants, among which he mentions *Ranunculus mutabilis*, *Trillium revolutum*, *Monarda pratensis*, *Eupatorium serotinum*, *Silene fistulosa*, *Cactus mesocantha*, *Hepatica parviflora*, etc., none of which he describes. The name *Eupatorium serotinum* was used by Michaux in 1803. Other proposed names which have not found their way into synonymy are *Gentiana glauca*, *Pediculars* [sic] *villosa*, *Martynia rotundifolia*, *Veronica connata*, *Zigadenus angulosus*. It is pointed out that *Gentiana amarelloides* Michaux is not the same as *G. quinqueflora* Linné, with which Pursh had confused it. Among some plants received 'from some ladies,' three new ones are mentioned: *Lysimachia* (*Trydinia*) *glauca*, *Gentiana azurea*, and *Trillium reflexum*, the latter 'differing from *T. sessile*, by its petiolated leaves, reflexed calyx and pale purple petals.' Some new names for plants from Missouri are *Gnaphalium nemocladum*, *Melothria alba*, *Asplenium glaucum*, *A. falcatum*, but which are also not described. *Melothria nigra* Raf. 'is common near Natchez.' And the following are recorded from Kentucky presumably for the first time: *Pancratium liriosme* Raf., *Iris brevicaulus* Raf., *Ptelea trifoliata*, *Arenaria divaricata*, *Lobadium trifoliatum* Raf. (*Rhus aromaticum* Ait.), *Triosteum minor*, *Nelumbium pentapetalum*, *Agave virginica*, *Iris cristata*, etc. In a postscript Rafinesque states that a new genus, *Geminaria*, must be formed for *Phyllanthus Carolinianus* Walter and Michaux (called *P. obovatus* by Wildenow, Persoon, Pursh, and Nuttall). Signed C. S. R.].

On the several species of the genus *Clintonia*, addressed to Dr. Samuel L. Mitchell, in a letter dated September 26, 1819 [pp. 42, 43. This is a review of the genus. The author reverses his former opinion that *Dracena borealis* Aiton, and *Convallaria umbellulata* Michaux are synonymous. Four species are recognized as follows: "1. *Sp. Clintonia nutans.* Leaves with ciliate margin, keel smooth: umbel sub-corymbose, pedicels smooth naked nodding unequal, perigone campanulate, sepals oblong sessile subacute.—*Dracena borealis* Ait. Wild. Pers. etc., flowers lerge [sic] yellowish inodorous. New York to Canada on mountains. Var. 1. *Prolifera.* Corymb proliferous.—Var. 2. *Fascicularis,* flowers in separate fascicles. 3. *Obovata.* Leaves nearly obovate. 4. *Dasistema*, scape pubescent. 5. *Macrostema.* Scape longer than the leaves. Var. 6. *Uniflora*, etc."

"2. *Sp. Clintonia podanisia.* Leaves with ciliate margin, keel smooth; scape pubescent longer than the leaves; umbel erect, pedicels unequal pubescent naked, the longest erect, the others incurved: perigone semi-campanulate, sepals oblong, sessile, acute.—Discovered in July, 1819, on the Laurel ridge in Pennsylvania. Flowers pretty large whitish, inodorous. Var. 1. *Biflora*, with only 2 flowers, the shortest with incurved pedicel, leaves narrow, semi-cuneate. Var. 2. *Glabrata.* Scape smooth. Var. 3. *Fascicularis.* 2 umbels, the second lateral, each with 3 or 4 flowers. Var. 4. *Phyllostema.* One small lanceolate and acute leaf on the scape."

"3. *S. Clintonia parviflora.* Leaves with pilose margin and keel, scape pubescent, equal to the leaves; umbel creet [sic]* 5–8 flore, pedicels equal, naked pubescent erect, perigone semi-rotate, sepals semi-onguiculated [sic], claws erect, disk oboval obtuse. Discovered in July, 1819, on the top of the Allegheny Mountains in Maryland. Flowers small, perfectly white, nearly inodorous. Var. 1. *Plicata.* Leaves folded falcated. Var. 2. *Abortiva.* Some abortive sessile flowers in the umbel."

"4. *Sp. Cintonia* [sic] *odorata.* Leaves oblong-oval, with ciliate margin and keel; scape pubescent, umbel erect, pedicels bracteated.—*Convallaria umbellulata* Mx. Pers.,

* Erect?

etc. This character is from the imperfect account of Michaux, who did not mention the shape of the perigone nor sepals; but the bracteated white fragrant flowers appear to entitle it to be deemed a peculiar species. Native of the Alleghany Mountains. Var. 1. *Punctata*. Flowers with red dots inside." Signed C. S. Rafinesque, and dated Lexington, 10th September, 1819.]

Pages 43–46. Agriculture. Practical Remarks and Results on the Agriculture of the Western States, or on the Cultivation of Corn, Wheat, Hemp and Tobacco in 1820. [Signed Agricola; dated Fayette county, Ky., 16th November, 1820.]

Pages 47, 48. Manufactures. On the various Manufactures from Flour. [Signed Agricola.]

Pages 49–52. Statistics. Statistical View of the Town of Lexington in Kentucky, in December, 1820 [p. 49. Signed M.]. View of the Public Institutions for Instruction in Spain and the United States [p. 50. Anonymous]. United States of America [p. 51. Signed Mentor]. Remarks on Public Instruction in the State of New York [pp. 51, 52. Signed Mentor].

Pages 53–57. Archæology. Alleghawee Antiquities of Fayette County, Ky., in a letterof Professor Rafinesque to the American Antiquarian Society. [Signed C. S. R. and dated Lexington, 3d January, 1821.]

Pages 57–59. Medicine. On some specific remedies for Mortification, Consumption, Hydrophobia, etc. [pp. 57, 58. Signed D. R.] Notices of Materia Medica, or new medical properties of some American Plants [pp. 58, 59. Medicinal properties are ascribed to *Erythronium albidum*, *Helonias angustifolia*, *Helenium autumnale*, *Evonymus atropurpureus*, *Euphorbia peploides*, *Triosteum major*, *Tr. minor*, *Sabatia angularis*, *Gentiana amarelloides*. Rafinesque states that he has found the Bear-grass, *Helonias angustifolia* Michaux to be different from *Helonias* and calls it *Cyanoteris pratensis*. Signed C. S. R.].

Pages 59–60. Discoveries. Selection of late American Discoveries. [Signed W. M.]

Pages 60–80. Literature and Varieties The Sifter.—No. 1. [pp. 60–62. Signed Z.]. The Querist.—No. 1. [pp. 62–64. Signed W. M.]. Female Free-Masonry.—No. 1. [pp. 64, 65. Signed O. I.]. Western Literature. Works published in the Western States in 1820 [pp. 66, 67. Signed W. M.]. The Sphynx.—No. 1. [p. 67. Signed Oedipus]. Polygryphs [p. 67. Signed Constantine]. The Monkeys.—No. 1. [pp. 68, 69. Signed P. Hystrix, M.D.]. Future Epitaphs. By Doctor Porcupine Hystrix, of Cincinnati [pp. 69, 70]. Fragments of Correspondence, containing Fragments of a letter of Mr. Bory St. Vincent * * * to Professor Rafinesque, [dated Bruxelles, 10 August, 1820], 'Annals of Physical Sciences' [p. 71]. Zoological Illustrations, by W. Swainson [pp. 71, 72]. Fragments of a letter to Mr. Bory St. Vincent at Paris * * * on various subjects * * * [Dated Lexington, 7th January, 1821. Rafinesque takes occasion to refer to his antagonists as a "set of unfortunate individuals, who have two eyes; but cannot see; their minds are deprived of the sense of perception; they are astonished and amazed at my discoveries, and are inclined to put them in doubt and even to scoff at them * * * our catfish, eels, shads [sic], sturgeons, etc., are for them mere fish to fill their stomach! and moreover they are all of European breed, and were carried here by Noah's flood direct from the Thames, the Seine and the Rhine! —I let them rail to their hearts' content, and I laugh at them * * *" and further he continues, "It is only in Europe that my labors and discoveries may be appreciated: here I am like Bacon and Galileo, somewhat ahead of the age and my neighbors; * * *" and further, "The *Western Minerva* has been threatened before her

birth" Signed C. S. Rafinesque]. Fragments of letters from Lexington. By a Lady [pp. 77–79. Deals with social life in Lexington. Signed Lavinia]. A view of some American Universities and Colleges in 1820 [pp. 79, 80. Signed W. M.]. 6. Transylvania University [p. 80. Signed W. M.].

Pages 81–88. Poetry. The Western Muse, or, Original Poetry. Les Rives de l' Ohio. Poeme en deux chants [pp. 81–82. Signed C. S. R.]. Couplet pour Silvie [p. 83. Signed C. S. R.]. A Melody, My Heart is Gone [p. 83. Signed M. T.]. A Melody. The Man I'll Love [p. 83. Signed Virginia]. La Double Aurore. Ode Anacreontique [pp. 83, 84. Signed C. S. R.]. Le Reveil d' Irma. Ode Anacreontique [p. 84. Signed C. S. R. and dated October, 1819]. L' Enfant et l' Epouse Endormis. Romance [p. 84. Signed C. S. R. and dated October, 1819.] Preceptes Moraux. 1. Le Secret d' etre hereux. 2. Amour et Jealousie [p. 84. Signed C. S. R.]. The Blind Lover [p. 85. Signed Milton]. Lines to Maria. Who asked me if I should like to Love in a Cottage [p. 85. Signed Constantine]. To Silvia [pp. 85, 86. Signed J. R.]. Trifles. By Billy Tickler of Frankford [p. 86. Signed B. T.]. Italian Stanzas. Un Consiglio d'Amore [p. 86. Signed Constantine]. Epigrams [p. 87]. The Elysian Dream. To my Sister [p. 87. Signed Eleonora]. To the Sun. To the Moon. On the Loss of a Friend [p. 88. All three signed Eleanora]. One Word and Only One. To Eliza. To Miss M——, who wished to know what she should read [p. 88. Both signed Oscar].

The copy of the work before me bears the autograph of S. S. Haldeman, one of the early members of the Academy of Natural Sciences of Philadelphia. It is known that Rafinesque advertised a copy for sale at $5.00, stating it to be unique, and it is not unlikely that the present one is that copy, which has been in the Academy's library for many years, although nothing is known of its history.

WM. J. FOX.

ACADEMY OF NATURAL SCIENCES
OF PHILADELPHIA.

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*THE INTERNATIONAL CATALOGUE OF SCIENTIFIC LITERATURE.**

I.—OBJECT AND NATURE OF THE CATALOGUE.

THE object and nature of the Catalogue were defined by means of the following resolutions of the 1896 Conference, which were agreed to *nemine contradicente*. The resolutions are re-numbered, but the original numbers are given in brackets :—

1. [12] That it is desirable to compile and publish by means of some international organization a complete Catalogue of Scientific Literature, arranged according both to subject-matter and to authors' names.

2. [13] That in preparing such a Catalogue regard shall, in the first instance, be had to the requirements of scientific investigators, to the end that these may, by means of the Catalogue, find out most easily what has been published concerning any particular subject of inquiry.

3. [17] That in indexing according to subject-matter regard shall be had, not only to the title (of a paper or book), but also to the nature of the contents.

4. [18] That the Catalogue shall comprise all published original contributions to the branches of science hereinafter mentioned, whether appearing in periodicals or in the publications of Societies, or as independent pamphlets, memoirs or books.

5. [25] That a contribution to science for the purposes of the Catalogue be considered to mean a contribution to the mathematical, physical, or natural sciences, such as, for example, mathematics, astronomy, physics, chemistry, mineralogy, geology, botany, mathematical and physical geogra-

*Scheme of publication approved by the International Conference of 1900.

phy, zoology, anatomy, physiology, general and experimental pathology, experimental psychology and anthropology, to the exclusion of what are sometimes called the applied sciences.

Technical matters of scientific interest shall, however, be included in the Catalogue, but shall be referred to under the appropriate scientific headings. (Rep. Comm., p. 5.)

II.—THE CONTROL AND MANAGEMENT OF THE CATALOGUE.

The control and management of the Catalogue has been provided for by the Conferences of 1896 and 1898 as follows:—

Definitions of the International Council, International Bureau, Regional Bureaus, and International Convention.

[The supreme control over the Catalogue is vested in an International *Convention*, which shall meet at regular intervals.

In the interval between two successive meetings in the Convention, the administration of the Catalogue is vested in an International *Council*, the editing and publication being carried on by a Central International *Bureau*.

The materials out of which the Catalogue is formed are to be furnished to the Central Bureau by *Regional Bureaus*.]

6. That the administration of the Catalogue be entrusted to a representative body, hereinafter called the International Council, the members of which shall be chosen as hereinafter provided.

7. That the final editing and the publication of the Catalogue be entrusted to an organization, hereinafter called the Central International Bureau, under the direction of the International Council.

8. That any country which shall declare its willingness to undertake the task shall be entrusted with the duty of collecting, provisionally classifying, and the transmitting to the Central Bureau, in accordance with rules laid down by the International Council, all the entries belonging to the scientific literature of that country.

[The organizations created for the above purpose are called hereafter Regional Bureaus. Each region in which a Regional Bureau is established, charged with the duty of preparing and transmitting slips to the Central Bureau for the compilation of the catalogue, is called a 'constituent region.' ('98.26.)]

9. In 1905, in 1910, and every tenth year afterwards, an International Convention shall be held in London (in July) to reconsider and, if necessary, revise the regulations for carrying out the work of the catalogue authorized by the International Convention of 1898.

Such an International Convention shall consist of delegates appointed by the respective governments to represent the constituent regions, but no region shall be represented by more than three delegates.

The decisions of an International Convention shall remain in force until the next convention meets. ('98.26.)

Of the International Conventions.

10. The rules of procedure of each International Convention shall be as follows:

(*a*) That English, French, German, and Italian be the official languages of the convention, but that it shall be open for any delegate to address the convention in any other language, provided that he supplies for the *procès verbal* of the convention a written translation of his remarks into one or other of the official languages.

(*b*) That there shall be Secretaries for the English, French, German, and Italian languages. ('98.3.)

(*c*) That the Secretaries, with the help of shorthand reporters, be responsible for the *procès verbal* of the proceedings of the conference in their respective languages. ('98.4.)

(*d*) That each contracting body (as hereinfter defined) shall have a vote in deciding all questions brought before the convention.

Of the International Council.

11. Each Regional Bureau shall appoint one person to serve as a member of a body to be called *The International Council.*

The International Council shall, within the regulations laid down by the International Convention, be the Governing Body of the Catalogue.

The International Council shall appoint its own Chairman and Secretary.

It shall meet in London, once in three years at least, and at such other times as the Chairman, with the concurrence of five other members, may specially appoint.

It shall, subject to the regulations laid down by the Convention, be the supreme authority for the consideration of and decision concerning all matters belonging to the Central Bureau.

It shall make a report of its doings, and submit a balance sheet; copies of which shall be distributed to the several Regional Bureaus, and published in some recognized periodical or periodicals, in each of the constituent regions. ('98.27.)

Each Contracting Body shall have one vote in deciding all questions brought before the Council.

[Pending the constitution of the International Council a Provisional Committee was appointed.]

Of the Central Bureau.

12. The Central Bureau shall be located in London. ('96.24.)

13. The Paid Staff shall consist of—

(i) A General Director who, under the International Council, and in accordance with the regulations of the Convention, shall direct, supervise, and be responsible for all the operations of the Central Bureau.

(ii) Expert Assistants skilled in the literature of various branches of science.

(iii) Such ordinary Clerks as may be necessary.

If the International Council so decide, there shall also be a Consultative Committee, appointed by the International Council, consisting of persons representing the several sciences, and residing in or near London. The Director shall be the Chairman of this committee. (Report of the Royal Society, p. 2.)

Of International Committees of Referees.

14. The following recommendations relating to International Committees of Referees are referred for consideration to the International Council when constituted. ('98.22.)

The International Council shall appoint for each science included in the Catalogue five persons skilled in that science, to form an International Committee of Referees, provided always that the Committee shall be as far as possible representative of the constituent regions. The members shall be appointed in such a way that one retires every year. Occasional vacancies shall be filled up by the Committee itself, subject to the approval of the Chairman of the International Council, and a member thus appointed shall hold office as long as the member whose place he fills would have held office.

It shall be the duty of the Director of the Central Bureau to consult the appropriate Committee or Committees, by correspondence or otherwise, on all questions of classification not provided for by the Catalogue Regulations; or, in cases of doubt, as to the meaning of those Regulations.

In any action touching classification the Director shall be guided by the written decision of a majority of the appropriate Committee, or by a minute if the Committee meets.

Provided always that when any addition to or change of the schedule of classification in any one branch may seem likely to affect the schedule of classification of some other branch or branches, the Committees concerned shall have been consulted; and provided also that in all cases of want of agreement within or between the Committees, or of other difficulty, the matter shall have been referred for decision to the International Council.

All business transacted by the Committees shall be reported by the Director to the International Council at their next ensuing meeting.

Of the Regional Bureaus.

15. In all countries in which, or whereever, a Regional Bureau is established, as contemplated in Regulation 8 (above), the Regional Bureau shall be responsible for the preparation (in accordance with Regulations hereinafter laid down) of the slips requisite for indexing all the scientific literature of the region, whatever be the language in which that literature may appear.

Each Regional Bureau shall transmit such slips to the Central Bureau as rapidly and as frequently as may be found convenient.

In the case of countries in which no Regional Bureau is established, the Central Bureau, failing other arrangements, shall, upon special mandate, endeavor to undertake the work of a Regional Bureau. ('98.24.)

III.—OF THE SUBJECT-MATTER OF THE CATALOGUE.

16. The following branches of science shall be included within the scope of the Catalogue, and shall be indicated as follows by the letters of the alphabet in consecutive order as *Registration Letters*.

A. Mathematics.
B. Mechanics.
C. Physics.
D. Chemistry.
E. Astronomy.
F. Meteorology (including Terrestrial Magnetism).
G. Mineralogy (including Petrology and Crystallography).
H. Geology.
J. Geography (Mathematical and Physical).
K. Paleontology.
L. General Biology.
M. Botany.
N. Zoology.
O. Human Anatomy.
P. Physical Anthropology.
Q. Physiology (including Experimental Psychology, Pharmacology and Experimental Pathology).
R. Bacteriology.

Technical matters of scientific interest shall be included in the Catalogue, but shall be referred to under the appropriate scientific headings. ('98.14 and Rep. Comm., p. 4.)

17. Schedules shall be approved by the International Council, in which the subject-matter of each of the above sciences is grouped under a convenient number of headings, each of which shall be indicated by an appropriate symbol. ('98.11, 15 and 21.)

In the first instance the schedules prepared by the Provisional International Committee shall be adopted, subject to such minor modifications of detail as may be found to be necessary in preparing the first volumes of the Catalogue. The symbols adopted to indicate the headings shall in the first instance be the numbers used for that purpose in those schedules. ('98. 20, and Rep. Comm., p. 5.)

After the publication of the first issue of the Book Catalogue, the Director of the Central Bureau shall consult the Committee of Referees as to the desirability of making changes in the classification, and shall report thereon to the International Council, who shall have power to authorize such changes to be made as they may think expedient. ('98.25.)

IV. OF THE FORM AND ISSUE OF THE CATALOGUE.

18. The International Council is instructed not to issue a Card Catalogue in the first instance, but if the finances permit, a Card Catalogue may be undertaken in future if approved by a special vote of an International Convention.

A Book Catalogue shall be issued in the form of at least one annual volume for each science, but parts may be issued at shorter intervals as the International Council may determine.

The International Council is instructed to proceed to the issue of bi-monthly or quarterly parts only if experience shows that such a course is desirable and financially practicable. (See Rep. Comm., p. 5, and '98.10.)

[Subject to any modifications which the experience of the Central Bureau may show to be desirable, Regulations 19 and 20 are submitted as embodying a scheme of publication.]

19. Since it is desirable to distribute the work of the Central Bureau and the printing of the Catalogue evenly over the entire year, the volumes shall be published in four groups as soon as possible after the first of January, April, July and October respectively.

[As an illustration, the two following schemes have been drawn up for consideration. The first, on the assumption that there will be a smaller number of editors than subjects, distributes the work in cognate subjects over the year.

The second is based on the assumption that there will be a larger staff of editors, so as to enable the volumes on cognate sciences to be published simultaneously.

Scheme 1.—To be published as soon as possible after—

January 1.	A. Mathematics. D. Chemistry. G. Mineralogy. L. General Biology. P. Physical Anthropology.
April 1.	B. Mechanics. H. Geology. M. Botany. Q. Physiology.
July 1.	C. Physics. J. Geography. N. Zoology. R. Bacteriology.
October 1.	E. Astronomy. F. Meteorology. K. Paleontology. O. Human Anatomy.

Scheme 2.—To be published as soon as possible after—

January 1.	A. Mathematics. B. Mechanics. C. Physics. E. Astronomy. F. Meteorology.
April 1.	D. Chemistry. G. Mineralogy. H. Geology. J. Geography.
July 1.	K. Paleontology. L. General Biology. M. Botany. N. Zoology.
October 1.	O. Human Anatomy. P. Physical Anthropology. Q. Physiology. R. Bacteriology.]

20. The titles to be indexed in each volume shall be those (not having been included in a previous volume) received at the Central Bureau from the Regional Bureaus not less than three calendar months, or such shorter period as the Central Bureau may fix, before the first day of the month in which the volume is to be published.

The first group of volumes shall be issued in July, 1901.

The second, third and fourth groups of volumes shall be issued in October, 1901, and in January and April, 1902.

The first literature to be included in the Catalogue is that of January, 1901.

21. The annual volume for each science shall contain :—

(1) The schedule of that science with the authorized registration symbols (see 17 above).

(2) An alphabetical index to the schedule, with the registration symbols attached. (Rep. Comm., p. 5.)

(3) An Authors' Catalogue.

(4) A Subject Catalogue (see 1 above).

22. The schedules and alphabetical Indices shall be printed either in English, French, German, or Italian, under conditions laid down hereafter (see 40 below). (Rep. Comm., p. 5.)

23. The Authors' Catalogue shall be ar-

ranged according to the alphabetical order of the authors' names, the full titles of the the memoirs or books of each author following his name in the order of the registration symbols by which they are indicated.

These titles shall be given in the original language alone if that language be either English, French, German, Italian or Latin.

In the case of other languages, the title shall be translated into English, or such other of the above five languages as may be determined by the Regional Bureau concerned (see 8 and 15 above); but in such case the original title shall be added, either in the original script, or transliterated into Roman script.

The title shall be followed by every necessary reference, including the year of publication, and such other symbols as may be determined. In the case of a separately published book, the place and year of publication, and the number of pages, etc., shall be given. ('98.18 and 25.)

24. The entries in the Subject Catalogue shall be primarily arranged in the order of the appropriate registration symbols in the schedules.

The order of arrangement in the final subdivisions shall in general, be in the alphabetical order of the authors' names, unless the subject demand other treatment. (Rep. Comm., p. 3.)

25. Each entry in the Subject Catalogue shall consist (α) of the author's name ('98.18, i); (β) of the title of the paper, or of a modified title describing the contents of the paper [or that portion of the contents of the paper to which the entry specially refers] better than the title itself (Rep. Comm., p. 4); (γ) of an adequate reference to the journal or other publication. ('98.18, i.)

The titles or modified titles in the Subject Index shall be given only in English, French, German, Italian or Latin.

If the title of the paper is not in one of these languages, the name of the language in which it was published shall be added, but the title or transliterated title in the original language shall be given in the Author's Catalogue only (see 23 above).

V.—OF THE LIST OF JOURNALS, COMMUNICATIONS TO WHICH ARE TO BE CATALOGUED.

26. Each Reginal Bureau shall, before November 30, 1900, furnish to the Central Bureau a list of the Journals, the contents of which it proposes to catalogue. Such Journals to be arranged in a list according to the order of the 17 sciences (see 16 above), which form the subject-matter of the Catalogue.

Journals dealing with science generally are to be placed under a special heading of 'General Science.'

Journals dealing with a limited number of sciences are to be placed under a special heading of 'Several Sciences,' and the sciences with which they deal clearly indicated by the registration letters of Section 16 above.

27. On receipt of the above lists the Central Bureau shall prepare for each of the 17 sciences a list of the Journals (whether special or general) dealing with that science, together with the abbreviated titles which it proposes to use.

Copies of these lists shall be furnished to each of the Regional Bureaus before January 1, 1901, and the abbreviated titles therein given shall alone be used by the Regional Bureaus in the slips (see 15 above) communicated by them to the Central Bureau.

28. A general list of journals indexed in the Catalogue, with the abbreviations to be used as references, shall be issued with the first edition of the Catalogue. A supplement, giving the additions to this list, shall be issued annually with a new edition at the end of five years. (Rep. Comm., p. 5.)

VI.—OF THE PREPARATION OF THE MATERIAL FOR THE CATALOGUE.

29. On and after January 1, 1901, or as soon after that date as the International Council may decide, the Regional Bureaus shall transmit to the Central Bureau the material to be indexed in the Catalogue, arranged on slips.

Unless otherwise ordered by the International Council—

30. The slips shall be of the character prescribed by the Central Bureau, and (except in the case of titles given in languages which do not employ Roman script) the entries thereon shall be either printed, typewritten or legibly written in Roman script.

31. At the head of each slip shall be given the letter and registration number indicating the science and subdivision of that science under which the material referred to on the slip is to be catalogued.

32. Unless the International Council decide otherwise, for each book or memoir to be catalogued, the Regional Bureau shall supply.

1. At least one copy of the entry for the Authors' Index, containing the material prescribed in Section 23 above.

2. At least one copy of each entry for the Subject Index, containing the material prescribed in Section 25 above, and Section 34 below.

The Regional Bureau shall retain duplilates until the volume containing the entries is published.

33. A paper or book shall be entered in the Subject Catalogue in more places than one only when this is rendered desirable by its scientific contents.

No exact limits to the number of entries to be allowed to single papers can at present be fixed. This must be determined by the Central Bureau, after adequate experience. Until such limits are determined, if the Central Bureau is of opinion that in the returns made by any Regional Bureau the numbers of entries to single papers do not correspond to the scientific contents, it shall be its duty to intervene; such intervention, however, to be based, not on individual cases, but upon an average. (Rep. Comm., p. 3.)

34. The International Council is instructed to direct the Central Bureau to aim at keeping the total number of entries in the Authors' and Subject Catalogues within 160,000, and not to exceed 200,000 entries without the permission of the International Convention. (See Appendix I.)

[Lists of species (see 16 above) must be reckoned according to the space occupied, as may be arranged by the Central Bureau.]

The Central Bureau is therefore instructed to reject less important entries, if this step is necessary to keep within the limits above laid down.

VII.—OF THE FINANCES OF THE CATALOGUE.

35. Any Body which establishes a Regional Bureau shall be termed a Contracting Body.

36. The number of copies of the catalogue due to each Contracting Body shall be sent to that Body, or to the corresponding Regional Bureau as such Body may direct, and shall be disposed of by that Body, by gift or sale, at its own discretion.

37. The Provisional Committee referred to at the end of paragraph 11 is instructed to negotiate with the several Contracting Bodies with reference to the sale in their respective regions of copies other than those subscribed for by the Contracting Bodies.

38. The various Contracting Bodies shall distribute the copies of the catalogue due to them in their own constituent regions.

39. Prices shall be fixed for the different volumes by the Central Bureau, and at the request of any Contracting Body, conveyed to the Central Bureau before a date to be fixed by the Central Bureau in any year, different numbers of the different volumes may be supplied to it during that year, pro-

vided always that the total value of such volumes does not exceed the value of the subscriptions received from that Contracting Body.

Unless a request to the contrary is received by the Central Bureau before the date fixed as above provided, the copies of the catalogue supplied in that year to any Contracting Body shall be a specified number of complete sets, *i. e.*, shall contain an equal number of all the volumes allotted to the different sciences.

If any Contracting Body requires a larger number of volumes than are covered by its subscriptions, such volumes may be supplied to it at specified prices to be fixed by the Central Bureau.

40. Any Contracting Body shall have the right to have the schedules and alphabetical indices prefixed to the volumes allotted to it in return for its subscription printed in English, French, German or Italian, as it may prefer.

If no request is made to the contrary, the language of the schedules and indices shall be English. (96.29.)

41. The total number of copies of the Catalogue printed in each year shall be in excess of the number allotted to the different Contracting Bodies to an extent to be fixed by the International Council.

The price at which the volumes are supplied to the Contracting Bodies shall be such as to cover the cost of production of such excess volumes, which, if wanted thereafter by any of the contracting bodies, shall be supplied to them at specified prices.

42. If the sale of the Catalogue or of the additional volumes result, in any year, in a profit, this profit shall be allowed to accumulate, and may be used by the International Council to cover a deficit in any other year; provided always that neither the scope of the Catalogue shall be increased, nor the total number of 200,000 entries exceeded, without the direct permission of the International Convention.

If the Catalogue shows a profit after several years' working, the International Convention shall decide how the profit is to be applied, whether to increase the scope or the bulk of the Book Catalogue, or to the issue of a Card Catalogue.

43. The publication of the Catalogue shall not be undertaken unless the shares taken up cover the estimated cost of the catalogue.

44. The publication, if undertaken, shall be an experiment for five years. All the Contracting Bodies shall agree to continue their subscriptions for five years, and the International Council shall not make contracts extending beyond that period.

THE AMERICAN MICROSCOPICAL SOCIETY.

The twenty-third annual meeting of the Society was held in New York City, June 28, 29 and 30, 1900. The regular sessions were held in Schermerhorn Hall, at Columbia University, and while the attendance was not large there was no lack of interest and of good papers.

The afternoon session of Thursday was confined to reports of the Curator, Secretary and Treasurer, and to a brief business session whereupon the Society adjourned to accompany Section F of the American Association for the Advancement of Science on a trip to the New York Zoological Garden.

In the evening the Society convened at the rooms of the New York Microscopical Society, 64 Madison Avenue, to listen to the annual address of the President, Professor A. M. Bleile, on 'The Detection and Recognition of Blood,' after which the visitors present were tendered an informal reception by the New York Society.

The morning session of Friday, June 29th, was devoted to the reading of papers after a short business meeting. The read-

ing of a tribute to Herbert R. Spencer was the occasion of discussion regarding the Spencer Tolles Fund which had grown to nearly eight hundred dollars. It was the general opinion that a united effort should be made to bring this fund at once to a point where its income would be available for the encouragement of research, and a committee was appointed to carry out the plan.

The Report of the Limnological Commission and papers on various subjects of fresh water biology occupied the afternoon session of Friday, and this program aroused active interest and discussion of the plan offered.

On Saturday morning the reading of papers was concluded, and the final business session closed the meeting. The following officers were elected:

President, Professor C. H. Eigenmann, Bloomington, Ind.; First Vice-President, Chas. M. Vorce, Esq., Cleveland, Ohio; Second Vice-President, Edward Pennock, Philadelphia, Pa.

Election Members of the Executive Committee. Dr. C. A. Kofoid, Urbana, Ill.; John Aspinwall, New York, N. Y.; Dr. A. G. Field, Des Moines, Iowa.

After the installation of the President and the customary resolutions of thanks, the Society adjourned.

The following papers were presented at the meeting in the order given:

'Photographing the Spectra of Colored Fluids,' by Dr. Moses C. White, New Haven, Conn.

'A Method for the Measurement and Demonstration of Size of Minute Bodies,' by Professor Henry B. Ward, Lincoln, Nebr.

'Herbert Spencer's Work,' by Henry R. Howland, Buffalo, N. Y.

'Methods in Embryology,' by Professor S. H. Gage, Ithaca, N. Y.

'A Comparison of the Development of the Larynx in Frogs and Toads,' by Professor S. H. Gage, Ithaca, N. Y.

'On the Distribution of Growths in Surface Water Supplies and the Method of Collecting Samples for Examination,' by Dr. F. S. Hollis, Boston, Mass.

'The Necessity of maintaining a System of Field Work on Surface Water Supplies,' by H. N. Parker, Boston, Mass.

'The Cladocera of Nebraska,' by Dr. Chas. Fordyce, University Place, Nebr.

'Biological Work at the Mount Prospect Laboratory,' by G. C. Whipple, Brooklyn, N. Y.

'Some New Forms in the Cave Fauna,' by Professor C. H. Eigenmann, Bloomington, Ind.

'The Modern Conception of the Structure and Classification of the Desmidiaceae,' by Professor Chas. E. Bessey, Lincoln, Nebr.

'Some North American Hydrachnidae hitherto Undescribed,' by Dr. R. H. Wolcott, Lincoln, Nebr.

'Limnological Studies at Flathead Lake,' by Professor M. J. Elrod, Missoula, Mont.

'Methods of Producing Color and Tone Effects in Lantern Slides' (illustrated by a series of lantern slides), by John Aspinwall, New York, N. Y.

'Some Notes on Bibliographic Methods in Microscopical Work,' by Dr. R. H. Ward, Troy, N. Y.

'A New Ear Fungus of Man,' by Dr. Roscoe Pound, Lincoln, Nebr.

'Methods in Killing and Staining Protozoa,' by Professor M. J. Elrod, Missoula, Mont.

'Synthetic Alcohol as a Fixing Agent for Tissues,' by Dr. T. E. Oertel, Savannah, Ga.

HENRY B. WARD,
Secretary.

SCIENTIFIC BOOKS.

The Birds of Celebes and Neighbouring Islands. By A. B. MEYER and L. W. WIGLESWORTH. Two Volumes. 4to. Berlin, R. Friedländer & Sohn. 1898. Vol. I., pp. i–xxxii, ***1–130***, 1–392, pll. 17 (14 colored), and 7 colored maps; Vol. II., pp. 393–962, pll. 28, colored.

Meyer and Wiglesworth's 'Birds of Celebes' marks an era in the history of East India ornithology. It consists of two volumes in quarto, with over eleven hundred pages of text and fifty-two plates and maps, nearly all colored. Although published in Berlin, by the well-known German publishers R. Friedländer & Sohn, it is in excellent idiomatic English, and should thus be especially welcome to English readers. In scope and character it is all that could be desired, being in short just the kind of work we should anticipate from such a source, the senior author especially having many years since attained an enviable prominence among the leading ornithologists of the world.

The field embraced in the present work is the East Indian Archipelago, or 'the island-world from Sumatra to the Solomon Islands and from the Philippines to the Lesser Sundas,' as shown in maps 1 and 2 accompanying the work. This area extends from Lat. 2° N. to 6° S., and from Long. 118° to about 127° E. It thus includes not only Celebes, but 'the Talaut Islands in the north, the Sulu Islands in the east, and the Djampa Group in the south.' It thus extends to the Philippines on the north, to Borneo on the west, and to Papuasia on the east. The Introduction (pp. *1–130*) includes a summary of 'Travel and Literature,' from the visit of Labillardière in 1793 to the expedition of Waterstradt to the Talaut Islands in 1897, with a special list of the literature on Celebes. Next are discussed the 'Seasons and Winds in the East Indian Archipelago' (with maps 3 and 4), in relation to their effect upon the dispersal, distribution, and climatic variation of the birds. This chapter gives a vast amount of information regarding the seasons and general climatic conditions of the various groups of islands from Borneo to New Guinea.

Under the heading 'Migration in the East Indian Archipelago' the general subject of migration is most intelligently considered, as well as the local movements and migration proper of the birds in the various islands. Although there is here a true migration of marked proportions, little as yet appears to be known as to its details, owing to the lack of competent resident observers.

'Variation' is considered under the following five heads: 1. Individual Variation; 2. Geographical Variation; 3. Seasonal Changes; 4. Sexual Differences; 5. Changes depending upon Age. Under 'Geographical Variation' these authors so well express the general concensus of ornithologists respecting the origin of new forms through geographic influences that the following statements seem of sufficient interest to warrant transcription: "Although it is conceivable, and indeed likely, that a new species may sometimes owe its origin to dimorphism * * * it is nevertheless far more certain that the great majority of the peculiar forms of Celebes and the neighboring islands are what are termed geographical species or local races, which have developed their distinctive characters while geographically isolated from one another. In the Celebesian area there are about 150 species of this description now known, not to speak of a large number of partially formed races. The latter are in many respects the most interesting, as they show species in the first stages of their differentiation, and their study holds out the best hope of solving the problem of the origin of species—or at least of the majority of species. The differences seen are often very small, but of a very palpable description * * *. These differences may be due to an inherent tendency in the individuals in question to evolve in a certain direction * * *, or they may be caused by local influences. For some cases the former assumption appears unavoidable; for other cases there is satisfactory evidence of the effect of local influences, though the exact nature of this latter is almost always uncertain; as a rule, probably, both causes operate together, but it very rarely happens that an opinion either way is permissible at present." Following this many instances of 'correlated geographical variation' in size and coloration are cited as characterizing representative forms in different groups of islands.

The subject of 'Sexual Differences,' so prolific of hypotheses, is treated at length, and with admirable conservatism. Eight of the leading 'theories of the origin of secondary sexual characters' are stated and made the subject of comment; six of them are presumed to have been 'actually operative in nature, working alone or more likely in different combinations and degrees.' Reasons are also advanced in support of 'the opinion that mutilations of feathers—and hence of other parts—if repeated for generations— are inherited.'

Under the caption 'Changes dependent upon Age' are discussed such interesting topics as 'ancestral characters,' 'hereditary effects of shelter and exposure,' etc., including the origin of 'racket-feathers' in groups of birds of very diverse affinities.

Some fifty pages are devoted to 'Geographical Distribution,' in which 'Wallace's Line' is considered at length. He leaves the prob-

lem undecided, and considers it, in the absence of geological evidence, a 'waste of time to speculate on it with the help of an up-and-down system for the islands and continents, just as required.' The local distribution of the Celebesian birds is presented in great detail by means of a series of tables, etc. Among the novelties of the work is an attempt to estimate the 'value of the affinities of the peculiar species of Celebes'; in other words, it is recognized that the various genera and species are not units of equal value in computing the relationship of the Celebesian avifauna to that of other neighboring countries. The conclusion reached is that the avifauna of Celebes "has far stronger connections with the Philippines than with any of the other neighboring lands, and that the relation of its birds with the Oriental Region is more than twice as strong as with the Australian Region."

The systematic part includes 393 species, and probably about 150 additional subspecies, all treated with the detail, as regards their bibliography, plumage, distribution, life-history, and affinities, that would be expected in a special faunal work of the magnitude and sumptuous character of the present admirable monograph. Dr. Meyer, the senior author, in addition to his high standing as an ornithologist, has the advantage of knowing personally the region to which the present work relates, he having spent three years (1870–73) in Celebes and neighboring islands, collecting much of the material (about 4000 specimens, now in the Dresden Museum) on which the 'Birds of Celebes' is based. He thus had an an opportunity of becoming familiar through actual field work with the geographical and climatic characteristics of the East Indian Archipelago. The numerous colored plates of previously unfigured species are well executed and form a fitting accompaniment to a work of high general excellence, and, moreover, a work which closes an important gap in ornithological literature.

J. A. ALLEN.

A Monograph of Christmas Island. London, British Museum (Nat. History). 1900. Pp. xvi + 337. 8vo. 22 plates, map and cuts. Christmas Island is a small body of land comprising about 43 square miles, situated in about latitude 10°, 30′ south, nearly 200 miles southwest of the western part of Java, from which it is separated by a depression of the sea floor some 3000 fathoms in depth. Though known to navigators since the middle of the seventeenth century, it has remained uninhabited until very recently, having been explored by Captain Pelham Aldrich R. N., in 1887, and annexed to the British crown in 1888.

It seemed highly desirable that this virgin island should be carefully examined and described by a competent naturalist and geologist before being opened up by Europeans for agricultural and commercial purposes. Accordingly it was arranged with the Trustees of the British Museum that Mr. C. W. Andrews, of the Geological Department, should be granted leave to carry out this exploration, the expenses of which were defrayed by Sir John Murray. Mr. Andrews spent ten months of 1897–98 upon the island and carried out the work with great success. The reports upon the geology and physical conditions of the island in this volume are from his pen, while the various subdivisions of the fauna and flora have been treated by a body of experts to whose descriptions Mr. Andrews has added many notes taken on the spot. The result forms perhaps the most elaborate account of an oceanic island ever published. Sir John Murray, who is interested in the company which has obtained a lease of the island for the purpose of developing its agriculture and deposits of phosphate of lime, intends to watch carefully the effects produced by the immigration of civilized man upon the fauna and flora, and record comparisons in the future for which the present volume will serve as a basis.

The island is of a roughly triangular form with projecting headlands and deep water for the most part close up to the cliffs or the narrow fringing reef which encircles most of the shore. It is in fact the flattish summit of a submarine mountain more than 15,000 feet high which rises some 1200 feet above the sea. The submarine slopes are about two in five, a depth of 6600 feet occurs in less than three miles from the shore and the foot of the mountain within twenty miles. The geological structure in brief,

consists of (1) a central core of older volcanics and Eocene or Oligocene limestones; (2) beds of basalt, volcanic ash and thick masses of Orbitoidal (Miocene) limestones enwrapping the core; (3) masses of talus derived mainly from the Miocene rocks and covered by (4) a thick detrital limestone which is derived from the wear of the reefs which cover the higher portion of the island; (5) a raised reef of much later date which covers the foot of the different slopes composed of 4; and finally (6) the late Pleistocene or recent limestones bordering the sea which cling to the base of any of the older formations which may be exposed.

The history of the island seems to include the deposition of several hundred feet of Eocene limestone on a bank with a volcanic basis; the gradual deposition, with slow depression, of masses of Miocene limestone; then a gradual elevation, with oscillations, during which guano was deposited on low atolls, forming the origin of the present masses of phosphate of lime; and finally the attainment of the present status of an elevated limestone island with interbedded volcanic layers surrounded by a narrow fringing reef of coral.

The prevalent wind on the island is the southeast trade, which blows on the average 300 days in the year, with occasional violent northerly storms. As it is the violent rather than the regular winds which transport exotic organisms to isolated islands, it is natural that a large part of the life on the island should be, as it is, intimately connected with the Malaysian types. Nevertheless, there is a recognizable portion of the fauna which is related to that of Ceylon and another to that of Australia, though the latter country is over 900 miles away.

Of the 319 species of animals recorded, about 45 per cent. are regarded as endemic, though a better knowledge of the fauna of Java may diminish this number. Of the plants about 10 per cent. appear to be peculiar to the island. Of both plants and animals not peculiar many have a widespread distribution.

Of the five mammals, two rats and two bats are peculiar to this island; while the shrew is regarded as a variety of a species inhabiting farther India. Thirty-one species of birds are noted, of which seven land birds are endemic. The other vertebrates include one snake (*Typhlops*), three skinks and two geckos, of which one skink and one gecko occur elsewhere. The pelagic species are not counted in the fauna, though three of them visit the island.

Of the landshells fourteen species are enumerated, of which six are local, but all belong to groups widely distributed in the Oriental region. Three out of nine butterflies, ten of the sixty-five moths, six of the nine Microlepidoptera, nine out of eleven Hymenoptera, fifty-six of ninety-four Coleoptera, four out of six Hemiptera, two of the five Neuroptera, fourteen of the twenty-two Orthoptera, three of the twelve Arachnids, and two of the four earth-worms are regarded as peculiar to the island.

The illustrations of the work are first-class, and the authorities of the Museum, Mr. Andrews and Sir John Murray, are to be congratulated on the manner in which the description of the island and the census of its organisms have been carried out. The work will doubtless long serve as a model for such investigations and it is to be hoped is the pioneer of many other monographs of a similar character.

Wm. H. Dall.

THE HUMANITIES IN HORTICULTURE.

The second volume of the 'Cyclopedia of American Horticulture,'* of which the first volume was noticed in Science for June 1st, sustains the high character evidenced in that volume, and is of more than usual interest to the general reader because it happens to include such general topics as greenhouses, herbaceous borders, horticulture, house-plants, labels, landscape-gardening and lawns. These are all so handled as to be interesting and suggestive as well as instructive. Plates 14 (the formal garden at Mt. Vernon), 15 (a modern informal garden), and 16 (a modern cemetery with landscape planting) are especially commendable illustrations.

W. T.

*Bailey, L. H. and Miller, W. *Cyclopedia of American Horticulture*, in four volumes. Vol. 2. E.–M. New York, The Macmillan Company. 1900. $5.00.

SCIENTIFIC JOURNALS AND ARTICLES.

The American Naturalist for July has for its first article some 'Notes on a Species of Pelomyxa,' by H. V. Wilson, which he names *P. carolinensis.* H. L. Osborn describes at length 'A Remarkable Axolotl from North Dakota,' but omits to give it a name, while W. M. Wheeler makes an important contribution to our knowledge of the driver ants under the caption 'The Female of Eciton Sumichrasti Norton,' with some Notes on the Habits of Texan Ecitons.' James A. G. Rehn discusses 'The Linnæan Genera Myrmecophaga and Didelphis,' concluding that *Myrmecophaga* is the generic name for the tree ant-eater, *M. tetradactyla* and proposing the name *Falcifer* for the great ant-eater, while *Didelphis opossum* is the type of that genus. C. R. Eastman reviews 'Karpinsky's Genus Helicoprion,' and in Part XI. of 'Synopses of North American Invertebrates,' Mary J. Rathbun furnishes the keys for 'The Catometopous or Grapsoid Crabs.' The Reviews are numerous and good.

IN *The Plant World* for July, Alice Carter Cook concludes her series of papers on 'Coffee Growing and Coffee Drinking'; Frank E. McDonald describes 'A Sand Dune Flora of Central Illinois'; C. F. Saunders propounds the query, 'Does the Catch-fly Grass catch Flies?' and E. J. Hill describes the habitat of 'Primula Mistassinica.' A. H. Curtiss discusses 'Some Nameless Plants' of Florida, and C. F. Saunders in the 'Etymology of Columbine,' suggests that it may come from *columbarius*, a dove cote. In the supplement devoted to 'The Families of Flowering Plants,' Charles L. Pollard continues a description of those of the order Farinosæ.

THE June number of the *Ottawa Naturalist* which constitutes No. 3 of Volume XIV. has just been issued by the Ottawa Field-Naturalists' Club. Among the interesting articles it contains we note one by Mr. Frank T. Shutt, chemist to the Dominion Experimental Farms, on 'Soils and the maintenance of their fertility through the growth of legumes.' This paper draws attention to investigations carried on in the fields and laboratories of the Experimental Farm with signal success. The improvement of soils through the growth of legumes has yielded results of the highest value to those who wish to maintain or recover the productiveness of their land. The next paper describes 'The Labrador Flying Squirrel.' Mr. J. D. Sornborger, of Cambridge, Mass., received three specimens of a flying squirrel from Rev. W. W. Perrett, of Makkovik, Labrador. These specimens on examination proved to be distinct from other species and have received the following name, constituting the new sub-species the 'Labrador Flying Squirrel' (*Sciuropteros sabrinus Makkovikensis*). Mr. Walter S. Odell, of Ottawa, contributes an article on 'The two-lined salamander' (*Spelerpes bilineatus*). A short note of the occurrence of the Squid in St. John Harbour, N. B., by Dr. Ami then follows, in which the writer points out that in Sept., 1899, the harbor of St. John and shores adjoining were literally infested with an unprecedentedly large school of squid. The same writer adds a brief note on some British American Echinodermata recorded in the *Challenger* Report on these organisms.

The Canadian Record of Science for January, 1900, which forms No. 3 of Volume VIII., contains the following papers and contributions to science: 'Sir John William Dawson,' by Professor Frank D. Adams, being an able though brief sketch of the life of that great Canadian scientist. It is followed by a letter from Sir J. William Dawson to the corresponding secretary of the Natural History Society and forms the last communication which he gave to that Society which for so many years he upheld by virtue of his own hard work and energies. 'Notes on some of the formations belonging to the Carboniferous system in Eastern Canada,' by H. M. Ami, in which the author discusses some of the problems involved in the classification of the different members of the Carboniferous in Nova Scotia. 'The flora of the Rocky Mountains,' by Rev. Robt. Campbell, M.A., is a contribution to botany of the Canadian Rocky Mountain belt in the broadest acceptation of the term. 'North American Goldenrods,' by Rev. Robt. Campbell, enumerates the different species and varieties of the genus *Solidago* contained in the herbarium of the Natural History